CHAPTER 14. RADIO FREQUENCY INTERFERENCE

1400. INTERFERENCE PROBLEMS. Being aware of an interference problem is essential before resolution can take place. To resolve interference, the FMO must be resourceful and have a wealth of experience and good technical references. This chapter outlines general procedures, however, the first action which an FMO should take upon notification of an RFI problem is to do a thorough desktop analysis of the situation to determine if there is an obvious solution. A more comprehensive treatise on interference problems will be found in the *Radio Frequency Interference (RFI) Detection, Analysis and Resolution* manual, prepared for FAA. It has been supplied to all regions by ASR and further copies are available upon request. Order 6050.22 prescribes policies and procedures for reporting and investigating intentional interference (phantom controllers).

1401. INTERFERENCE REPORTING. Whether the interference problem is resolved locally or not, it is very important that the problem and its resolution be reported to ASR. Occasionally, ASR receives inquiries, Congressional and otherwise, concerning ongoing interference problems. Headquarters must be in a position to report promptly on the status of any problem at any time. The following guidelines shall be used for RFI reporting:

a. Use the Maintenance Management System (MMS) in lieu of FAA Form 6050-3, Frequency Interference Report. MMS entries are normally done by either the SMO or the Maintenance Control Center (MCC).

b. If there is an RFI-associated facility or service interruption, use the Interrupt Report (LIR) log.

c. If there is no RFI-associated facility or service interruption, use the Line/Frequency (LLF) log.

d. For both the LIR and LLF:

(1) Enter 84 in the CODE CAT field

(2) Enter the duration of the RFI in the OPEN/START and ENTRY/CLOSE fields.

(3) Enter the affected frequencies and channels in the appropriate data fields.

(4) Enter a brief description of the interference and information regarding any actions started or completed in the COMMENTS field. Additional comments may be added by supporting organizations, e.g., SMO, regional FMO, etc.

e. If required, separate logs should be created for each RFI incident and linked to the parent log via the RELATED LOG ID field.

f. The FMO must use good judgment. The nature and particularly the impact and importance of a problem must be carefully weighed. If there is a reasonable chance that it might be of immediate interest to headquarters, ASR shall be advised immediately. At least the following types of problems warrant a call to ASR, followed by documentation:

(1) Problems with equipment design or design deficiency.

(2) Problems dealing with major or hub airports.

(3) Problems indicating FAA and FCC/NTIA frequency standards are in conflict.

(4) Any interference receiving media attention.

(5) Any interference connected with an accident or incident.

(6) Any interference which might arouse political or aviation community interest.

(7) Any interference causing a facility to be shut down or restricted.

(8) Any interference to high frequency assignments.

g. The MMS Report format is shown in detail in Order 6000.48, General Maintenance Handbook for Automated Logging.

1402. ADMINISTRATIVE PROCEDURES. Determining the source or cause of the interference determines the administrative procedures required for resolution.

a. If the source is non-Federal, the FCC has jurisdiction, and the appropriate FCC Field Office shall be contacted by the FMO. Once a source is pinpointed, judgment must be exercised in approaching the source owner. FCC should be contacted first, since they may wish to use administrative or other legal procedures. Follow the guidelines in Order 6050.22.

b. If the source is another Federal Agency, two options are available. One is to notify ASR and let them coordinate at the Washington level. A second is to contact the agency's technical person responsible for the operation of the offending equipment and resolve the matter locally, reporting the resolution to ASR. In this regard, participation by the FMO in local organizations of federal frequency managers and technicians is encouraged.

c. When FMO's require airborne RFI support, it will be requested through the MCC. The request will be followed up by a letter to MCC with copies to ASR-1 and the Program Director, Aviation System Standards (AVN-1). A simple form letter should be developed by regional FMO's for this purpose.

(1) ASR requests for airborne RFI support will be requested directly to AVN. This request will also be followed up by letter.

(2) In all cases, accurate records should be kept of funds expended to investigate the RFI.

(3) The use of non-FAA aircraft for RFI investigations must be specifically authorized by ASR-1 and is only allowed if the FAA does not have to pay for the aircraft use.

d. Policy on use of multicouplers/combiners to resolve cosite problems is addressed in paragraph 904h.

1403. INTERNAL PROCEDURES. The manner of proceeding to resolve an interference case can vary from region to region, depending on the regional organization and the FMO's position in that organization. Nevertheless, the following is recommended as a minimum standard:

a. Establish SMO frequency coordinators at the SMO level. Technical personnel at the SMO headquarters are good prospects. It is beneficial to note that a facility off the air for interference is counted as an outage just as if the equipment were defective.

b. Encourage SMO frequency coordinators to meet with AT and FS managers to assure their reporting of any interference to the SMO promptly.

c. Initiate discussions with AT and AF operating Branches within the regional office toward increasing their awareness of the need for promptly reporting interference to the FMO or the SMO.

d. Notify the responsible party immediately, usually the SMO, when an interference problem has been found to be a defective FAA transmitter. FMO assistance should be offered in pinpointing the cause. This best can be done by providing confirming on/off test certification, remedial filter recommendations, suggestions based on past experience and engineering observations using FMO interference locating and measuring equipment.

e. Consider use of the "seamless" region concept (see paragraph 503a) to provide timely response to those RFI incidents which are particularly critical.

1404. INTERFERENCE LOCATING EQUIPMENT. The equipment which can be used in interference location is limited only by the imagination and ingenuity of the FMO. The RFI manual referred to in paragraph 1400 is a detailed source of information on this subject. There are some basic standards that can be counted on reliably:

a. The telephone is a primary tool for investigating interference problems. The ability to talk with operators of suspected sources is crucial. If the FMO has a list of contacts for FCC, other Federal Agencies, Department of Defense Area Frequency Coordinator (DOD AFC), a call to the right person with a description of the nature of interference frequently may bring resolution.

b. The human ear is priceless in identifying interference sources. It is nearly always the sound that gives the source an identity. "Plastic welders" have a very distinct sound as they sweep through a communications receiver pass band. Careful listening to the signal or reviewing AT tapes can reveal such things as:

(1) Service -- whether it is police business, taxi dispatching, amateur, etc.

(2) Emission -- pulse modulation such as radar, ATCRBS, and other pulse type emissions are recognizable by their characteristic "buzz."

(3) Nature -- the sweep of a frequency by an industrial heating device, the characteristic of a video field change "buzz," the rhythmic ticking of a timing circuit and the musical sound of a varying telemetry signal are examples.

c. A spectrum analyzer (SA) is an excellent tool, but it must be used with caution. It is particularly valuable for short duration or "burst" type interference, especially if a storage mode is available. Likewise, when a complex wave shape is involved, the only way it may be recognized or interpreted is with the use of an SA or oscilloscope. For instance, a video interfering source may sound like a 60 Hz buzz, but on an SA or an oscilloscope connected to a detector, it would be positively and immediately identified as a video source, with the sync pulse and pedestal clearly showing.

(1) The major caveat in the use of an SA is that its untuned front end (at least below 1 GHz) can generate spurious signals which may appear as if they were real signals, and also false signal levels due to front end overloading. The standard procedure should always be to use a tunable filter ahead of the analyzer. This will permit on-frequency use while rejecting off-frequency sources.

(2) If no filter is available, then the following procedure will permit assuring that overload is not occurring. Tune in the signal on the SA and note it and any adjacent signal levels. Insert 10 dB additional attenuation. If all signals presented on the screen drop 10 dB, then the front end is not being overloaded (provided a wide enough spectrum is being measured). If some drop more than 10 dB, then the front end is overloaded, and another 10 dB attenuation is required. When a level of additional insertion occurs where every signal drops equally, the integrity of the front end of the SA is assured. (Note: The more attenuation that must be inserted, the less sensitive the SA is to the RFI source).

d. A receiver covering the frequencies under consideration is often the best device, whether it is a many thousand dollar field strength meter or an inexpensive plastic-cased portable. The better the shielding and selectivity, the better the results will be. Even a 360, 720 or 760 channel VHF A/G transceiver can be reasonably effective in the VHF range under some circumstances. A receiver which permits an external antenna to be used, has RF gain control, is shielded and has a carrier level meter is ideal. Some of these receivers have been purchased by regions over the years and are being used. FMO's are encouraged to watch for such receivers which could be used for this purpose and to notify ASR.

e. A suitable antenna connected to a receiver for direction-finding (DF) can provide a big boost in quickly locating a source. A loop, yagi, or even a simple dipole which can be used for DF, will work wonders if properly used. Details are in paragraph 1406 b. and in the RFI manual described in paragraph 1400.

f. An RFIM van or vehicle is an efficient tool when used by a proficient operator, especially if the source is suspected to be at some distance from the victim receiver. The ability to take bearings quickly, ideally while traveling, assists in rapid DF triangulation that leads to source location. Detailed information concerning RFIM vans will be found in chapter 15.

g. DF's, whether fixed or portable are ideal tools. There are fixed DF's at some FSS's. Each FMO has been supplied with a "suitcase portable" which can be used in a vehicle while in motion and hand-held DF systems with loop and yagi antennas.

1405. INTERFERENCE LOCATING TECHNIQUES. The techniques for locating an interference source are as varied as are interference sources and people. A principal tenet is that no condition is to be assumed. All possibilities must be considered. Some basic techniques have been developed over the years. These are detailed in the following paragraphs, listed by the type of system receiving interference.

a. Communications interference to ground receivers is by far the most common and is classified into three basic areas: internal, local, and external.

(1) Internal interference is that generated within the communications receiver. "Birdies" are harmonics or spurious emissions generated by internal crystal oscillators or synthesizers used in the superheterodyne action. They manifest themselves as unmodulated carriers on specific frequencies, appearing constantly. The FMO should not assume that because interference suddenly appears that it must be external. An aging crystal, "tweaking" of oscillator tuning during routine maintenance and a change in a receiver voltage bus due to any cause can initiate a spurious signal where none had appeared before. Determination is simple. Remove the antenna from the receiver and ground the input terminal. If the signal remains, the source is internal and the receiver should be repaired.

(2) Local interference is that caused by other signal sources in the same rack, same room, or same building. It is a signal generated by another transmitter or receiver, which causes a receiver response on the assigned frequency. The FMO should not assume upon receiving a complaint that the interference "just" started. It could have been present since installation of the victim receiver or the source transmitter or receiver, but only recently became noticeable. Problems can be masked by normal squelch setting and then become noticeable only when the squelch level is lowered or increased traffic on the frequency causes the squelch to be opened more frequently.

(a) At the time the frequencies at the same site were engineered, the lower order intermods should have been considered and eliminated. Intermods are covered in the appendix for NAVAIDS and the appendix for COMM. Occasionally, a third or fifth order low-level intermod will "hide" below squelch until frequent use of the frequencies divulges it. Intermod is easily recognized by its make up of a mix of two or more local frequencies other than the victim frequency.

(b) Some remedies are:

1. Antenna relocation (vertical or horizontal separation).

2. Receiver or transmitter relocation to another site.

3. Cavity or crystal filter installation at the victim receiver input.

4. Cavity and/or ferrite isolator installation at transmitter outputs.

5. A frequency change is absolutely the last resort. However, there comes a time when to solve a problem which may have taken a great deal of manpower and time, a frequency change must be considered. There is an ever-present danger that a change will create a new problem, so this step must be taken only after thorough consideration.

(3) External interference can be caused by a myriad of sources, including such devices as heater thermostats, broken power pole insulators, spark ignitors for gas heaters, doorbell transformers, computers, any number of industrial devices using electrical or RF energy (such as "plastic welders") and almost any conceivable RF source. The problems divide into six categories: cochannel, adjacent channel, brute force, intermod, image and audio rectification.

(a) Cochannel interference occurs when a signal is generated that falls within the receiver band pass of the assigned frequency. The victim receiver does not know that the signal is spurious or harmonic from a transmitter on an entirely different fundamental frequency. It only knows that it receives a signal at its detector that needs processing. The initial task for the FMO is to identify the signal (voice, pulse, etc). This can be done by listening to the interference directly or from AT tapes, if available. Procedures and equipment described earlier in this chapter should be used.

(b) Adjacent channel interference is essentially the same as cochannel, except the signal is much stronger or much broader. The receiver band pass is a product of its RF and IF band pass circuits, but they are limited in their curve shape due to the Automatic Gain Control (AGC) function, which in turn depends on the strength of the signal.

(c) Brute force, also called front end overload, is an exceedingly strong signal which might be anywhere in the spectrum. As an example, a 50 kW FM broadcast transmitter in the 88-108 MHz band a few hundred feet from a 118-137 MHz receiver can completely overload the receiver. The result is desensitization of the receiver and usually the passing of the FM signal through the receiver. Brute force can also be in-band and near-frequency. For instance, a receiver tuned to 125.575 MHz would undoubtedly receive devastating interference from a transmitter on 125.60 MHz in the vicinity, assuming its antenna were in proximity. Adjacent channel and brute force problems can normally be cured only by relocating the transmitter or receiver antenna to achieve 1,000¢ or more separation or the installation of a cavity or crystal filter. Details on these filters will be found in the appendix and the RFI manual referenced in paragraph 1400.

(d) Intermod (IM) interference normally occurs in a receiver, caused by a combination of external strong signals (2 or more) which algebraically mix to produce the victim frequency, usually in the first mixer or first amplifier. The receiver responds to the mixed frequency as if it were an "on frequency" signal. This problem is detailed in the appendix. Intermods may also occasionally be created within transmitters where they are in close proximity. An SA could be of valuable assistance in determining the interfering signal level.

1. The definition of an intermod is expressed as the result of formulas where various frequencies are acted upon mathematically and the final result is the IM to the victim. For example:

- 2nd harmonic = 2F
  121.5 x 2 = 243.0

- 3rd harmonic = 3F
  121.5 x 3 = 364.5

- Sum/difference = 2F1 ± F2 = IM
  (121.5 x 2) - 118.7 = 124.3
  (121.5 x 2) + 118.7 = 361.7

- 3 frequency = F1 + F2 ± F3 = IM
  118.2 + 124.5 + 119.6 = 362.3
  118.2 + 124.5 - 119.6 = 123.1

Note: This type of problem normally occurs within the same building, or nearby buildings. To minimize brute force (overload) potential, the FAA cosite standard for frequency separation is 0.5 MHz for VHF (118-137 MHz) and 1.0 MHz for UHF, (225-400 MHz) for T/R antennas within 80' of each other.

2. **One remedy for receiver intermod** is to install a band-reject filter at the input of the victim receiver, tuned to the undesired frequency. This reduces the undesired signal below the level at which it drives the victim receiver front end into non-linear operation, the proximate cause of the intermod problem.

3. **A second remedy for receiver intermod** would be to use a bandpass filter at the victim receiver, tuned to the victim frequency. This is effective, however, only if the culprit frequencies which cause the intermod are well removed from the victim frequency. The frequency separation requirement is a function of the bandpass filter curve skirts.

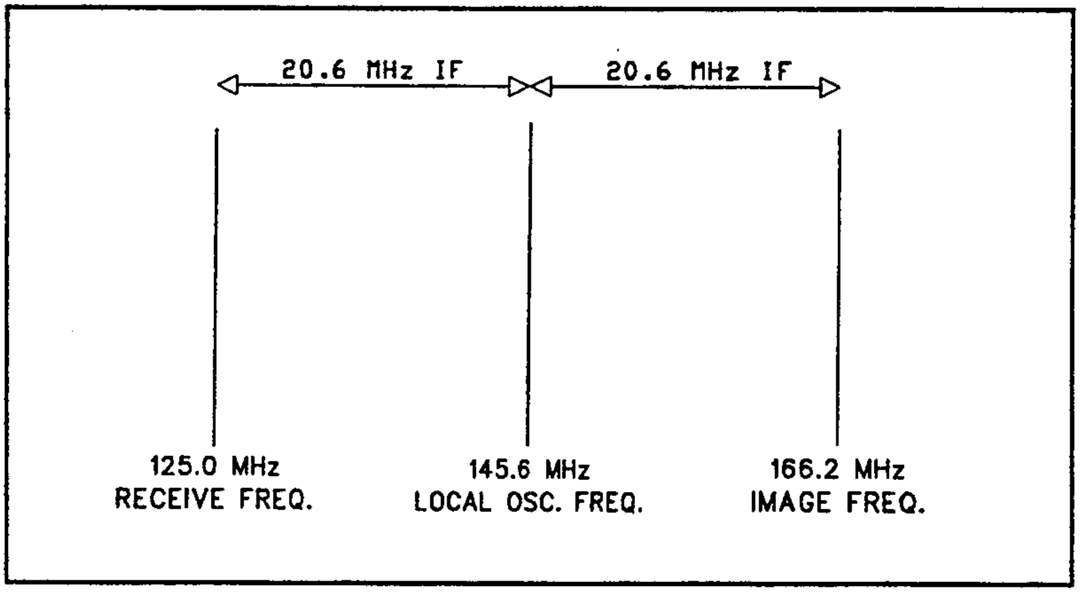
4. **The only remedy for transmitter intermod** is to use either bandpass or band-reject filters at the antenna input of the culprit transmitter. Here, a similar situation occurs, whereby the proximity of strong signals causes a mix in an amplifier or mixer stage. However, in this case, it is the transmitter final amplifier which is driven by external signals into non-linear operation, generating and radiating the undesired spurious signal on the victim frequency. Since a transmitter is actually radiating a spurious signal, nothing can be done at the receiver to remedy the problem, only stopping the undesired signals from entering the culprit transmitter is effective.

(e) Image interference is caused by a strong external signal which mixes with the local oscillator (LO) in the victim receiver to produce the intermediate frequency which then is processed by the receiver just as if it were a desired "on frequency" signal.

1. **An example** of the process is as follows. A receiver is tuned to 125.00 MHz. Its LO is 20.60 MHz ABOVE the desired frequency. If a sufficiently strong signal appears at the victim receiver input, a culprit frequency of 166.200 MHz will get through the first amplifier of the receiver and mix with the 145.60 MHz LO to produce the intermediate frequency of 20.60 MHz. See figure 14-1. Were the LO on the LOW side at 104.4 MHz, the "image"

frequency would be 83.80 MHz, very close to TV channel 6 video carrier.

FIGURE 14-1. IMAGE FREQUENCY RELATIONSHIPS



2. **The remedy** for image interference is the same as for intermod. It is necessary to filter out the undesired signal from entering the victim receiver by reducing its level below that to which the receiver will respond. The amount of rejection required will depend upon the bandpass skirt selectivity of the victim receiver front end amplifier. The other alternatives are to lower the power of the culprit transmitter, install a directional antenna which discriminates against the victim-culprit azimuth or to move one of the sites further away.

3. **The commonly used** VHF/UHF COMM receivers for FAA are the GRR-23, GRR-24 and the CM200V/UR units. The GRR LO's are 20.6 MHz above the desired frequency, except for 322 MHz and higher, where they are below. All CM200 series LO's are 45.0 MHz above the desired receive frequency. The CM200 also has a second IF at 456 kHz.

(f) Audio rectification is a different sort of problem, but is caused by an external source. It is the situation whereby an audio amplifier is driven into detection mode by the strength of the culprit signal, usually a nearby AM broadcast station. At some strength level, any signal can cause a contact (this can be a solder joint, a transistor input junction, a poor ground connection, etc.) to act as a diode and rectify and reradiate the detected signal. Sometimes the signal is badly distorted because it is the increase in intensity from the amplitude modulation that pushes the device "over the edge" into detection mode. This is a case of a portion an amplifier acting as a radio receiver. It usually is at the input stage where the amplification is the greatest and the rest of the amplifier merely amplifies it.

1. **One remedy** is to bypass the input circuit with a small (0.005mfd or

so) capacitor between chassis (circuit board) ground and the closest possible point of input to the amplifier stage, with the shortest possible leads. Also useful is a ferrite bead on the input line wire.

2. **Another remedy**, if the strong signal is entering the amplifier cabinet by the power line or remote speaker lines, is to wrap the line through a ferrite ring which will act as a radio frequency choke.

3. **Sometimes** merely plugging in the power cord to another outlet circuit will change the level enough to eliminate the rectification.

4. **Each case** is unique to the station source and the various parameters of the amplifier and must be attacked in a logically progressive manner.

b. Communications interference to aircraft receivers can be difficult to investigate and locate. Because of RLOS, the RFI source affecting a flying aircraft may be located a hundred miles or more from the area where aircraft are being affected. The following procedure is recommended for investigation and location of such RFI sources.

(1) Obtain the following data from AT:

(a) The time the RFI reports started.

(b) Aircraft location (including altitude), airline if commercial, and types of aircraft involved.

(c) Is the RFI constant or intermittent - night, weekends?

(d) Description of the RFI - music, voice, squelch breaks, tones.

(2) If the RFI is fairly constant, and only one airline reports the problem, suspect their equipment and contact their maintenance department with the information you have obtained from AT.

(3) If the RFI is fairly constant and several airlines and private pilots have reported the problem:

(a) Request AT's asking aircraft at various altitudes in the affected area to monitor the frequency for RFI (targets of opportunity).

(b) When AT supplies the data, plot the extremes at which multiple RFI reports have been received on a sectional map.

(c) Identify an area of 50 nmi radius or less having the majority of RFI complaints.

(d) Conduct the following flight checks in an attempt to reduce the size of the area to be searched on the ground.

1. **Altitude** - 10,000¢ above local ground level

2. **Area** - 50 nmi east, west, north to south radials centered on the problem area.

3. **Record the AGC level** when the RFI is present on the frequency or note on a chart the area where the signal is the strongest.

4. **By triangulation**, estimate where the RFI source is located.

5. **Repeat steps a, b and c above**, but this time fly at 2,000¢ or 3,000¢ AGL above the location estimate in step 4 above for a distance of 20 nmi east to west, north to south. This will fine tune the RFI source location estimated in step 4.

6. **Proceed with the ground search** of the area identified in 4 and 5 above.

c. NAVAID interference is usually more difficult to identify. Generally, any interference is first noted in the air by a pilot. Unless the source is very strong, there is a good possibility that it cannot be heard on the ground, except in the immediate vicinity of the source. It may be necessary for the FMO to arrange airborne RFI support for such investigation. If so, refer to paragraph 1402 c. for the procedure.

(1) Interference to VOR locally may be reported principally on an airport. In this case, it would be worth trying a ground search with the RFIM van on and around the airport first, or using a hand-held DF system.

(2) Interference to VOR and LOC frequently is from FM broadcast stations, especially if they are in the upper part of the 88-108 MHz band, creating brute force and intermod problems in the airborne receiver when the aircraft nears the FM transmitter site. Unless the FM station is clearly identified by the reporting pilot, it will be necessary for the FMO or FI to observe reception of the signal in the air. The FMO should not hesitate to request a flight with FI to make a definite determination whether a reported interference is really a problem or a problem in the reporting aircraft equipment. Request the appropriate Air Traffic Control Tower (ATCT), Terminal Radar Approach Control (TRACON) or Air Route Traffic Control Center (ARTCC) personnel to query aircraft of opportunity to check whether they notice a reported problem before investigating a report. Here again, the FMO must exercise good judgment. It is generally a good idea not to react to only one report, but wait until others come in, unless, of course, the report is from FI which was observed on their equipment. The appendix describes techniques to prevent this problem.

(3) Interference to TACAN can be caused in two ways. Airborne reception can be affected by a source somewhere on the ground. The ground-based TACAN receiver can receive interference from any source nearby on the ground or from any airborne source within RLOS. Working with an SMO frequency coordinator or SMO technicians is necessary so that the FMO can know whether to work with the interrogator or transponder frequency. Once the geographical area is known, the FMO should proceed to locate the source, using the techniques described in this chapter.

d. Radar Interference.

(1) Primary radar interference and its associated beacon present a particular problem in locating an RFI source. Primary radar interference is normally another radar, although occasionally it is a harmonic from a lower frequency transmitter. The FMO should coordinate with SMO technicians to determine the azimuth the interference indicates on the scope. If the source is another radar, the interference may appear as dotted spirals called "running rabbits," which appear to "run" as the radar rotates. If the FMO has good records from the radar coordination program, the source might be identified by the PRR. There is a method to determine this from the radar scope presentation and it is detailed in paragraph 1408.

(2) Radar Beacon (ATCRBS or IFF) interference is most difficult of all because all interrogators and transponders work on the same frequency (1030/1090 MHz) and are separated only by PRR. Interference is usually from another interrogator which could be several hundred miles away. Interference will normally show up as intermittent false targets. This is because an aircraft can be illuminated by two different interrogators at nearly identical times, resulting in both radars "painting" both replies, offset in time.

(a) It will be necessary to determine in what general area the aircraft are located which are producing the false targets. Coordination with AT is essential. Once the area is known, monitoring of 1090 MHz should be done, looking for aircraft replies on the same PRR (±3 pps) as the victim radar. From there, it becomes trial and error plus deduction. If the direction of victim aircraft can be determined, that would be a good start. In any event, the area of search will have to be widened until an interrogator on 1030 MHz can be heard that matches the PRR of the victim. It is then located by DF procedures, as described in paragraph 1407.

(b) Since beacon interference is almost always caused by another interrogator, the FMO needs patience and diligence to locate it. The use of telephone contacts, particularly with DOD spectrum coordinators and appropriate on/off tests, are clearly indicated before a ground search is begun. Here is where the FMO's PRR coordination records, contacts set up in advance with DOD, other spectrum coordinators and the telephone are usually the most valuable tools.

(3) Reflections from metallic objects such as buildings, fences and the like can cause interference by putting the source radar signal into areas not intended. See paragraph 1302 and figure 13-1.

1406. DF (BELOW 1000 MHZ). When telephone and record searching procedures do not locate a source, the next logical procedure is to use DF. The principal procedures are automatic DF, directional antenna DF, and "hot and cold" DF. They apply equally to use in an RFIM van, a vehicle mounted auto-readout or hand-carried portable. A detailed guide for DF in this range and also above 1000 MHz will be found in the RFI manual referenced in paragraph 1400.

a. Automatic DF is ideal. Most models use a set of ground plane verticals, switched at a rapid rate, with readout of the incoming signal by compass strobe or digital azimuth. Automated models give computer readout as well. With these devices, the FMO merely follows the direction indicated until the source is located. The FMO must be aware that when using such a device, many false bearings will appear during approach to the source which are caused by reflections.

b. Directional antenna DF is a style frequently used because of availability and relatively low cost. The antenna is connected to a suitable receiver, which should have a signal strength meter for best results. Lacking a meter, aural signal intensity variance can be used. For a loop or dipole, a signal null is used, because the null is much sharper than the maximum. For a yagi, horn, or other high gain antenna, the maximum is used. This is not because the maximum is sharper, but rather because the nulls in these kinds of antennas are varied and not diametrically opposed, so that confusion in determining the actual bearing could occur.

(1) For a loop, electrically one half wave or less, the minimum or null signal is perpendicular to the plane of the loop. That is, when the loop is rotated, the signal meter or audio level will vary so that looking through the loop when the signal is nulled or at minimum will indicate the direction of the signal being received. A loop bearing is bidirectional. Since the loop is symmetrical if balanced (reasonably so, if not), the source can be either in front or behind.

(a) To determine which, after the first bearing, move off to near a right angle to the first bearing, a few hundred or a thousand feet. Take another bearing. If the source is within a mile or so, the second bearing will cross the first and thus establish direction ahead or behind. A greater right angle distance may be required if the source is at a considerable distance.

(b) Next, travel to the general area of the bearings_ intersection and take a third bearing. Plotting it should create a triangle with the first two. The source should be in or near the triangle, actually located by continuing triangulation and narrowing the search area.

(2) For a dipole, the process is the same but the indication is reversed. A dipole minimum or null is off the ends of the dipole, along its plane. In effect, the dipole null "points" to the source. Because it is not electrostatically shielded like a loop, a dipole is subject to many more reflections. The FMO must be careful in following the bearing, making frequent stops for bearing (unless bearings are made while traveling, such as in the RFIM van). Like the loop, the dipole is bidirectional. If it is not adjusted to resonant length it may not have symmetrical nulls.

(3) For a whip or unipole, the procedure is the same as the dipole. A whip is normally attached to the receiver antenna input connector. The receiver or antenna is rotated so that the plane of the whip is horizontal. It is then used just as a dipole. Although less effective than a dipole, a whip can be used satisfactorily, if the signal is reasonably strong, or the receiver very sensitive. In addition, a certain amount of directivity can be obtained by holding the receiver and antenna in front of you. As you rotate about on your heel, one null may be "deeper" than the other. If this is the case, chances are your body absorbs some of the VHF signal when it is at your back, so the "deeper" null could indicate the signal source is to your back.

(4) A yagi, corner reflector or other multi-element antenna is unidirectional. A signal strength meter on the receiver or other level readout is essential. In use, the maximum received signal is used as the bearing, and the broad nose of the beam can be centered only by use of a meter or other signal level readout. Nulls are asymmetrical, thus unusable. There are three advantages to a yagi, corner reflector or beam antenna:

(a) Each produces gain.

(b) Each is unidirectional, so that the source direction is always known.

(c) Each is polarized, so that above approximately 100 MHz, the antenna can be rotated on its directional axis to determine the signal polarity and thus minimize reception of cross polarity undesired signals.

(5) All antennas mentioned in this paragraph are effective. All should be operated away from metal or other RF reflective surfaces to prevent any reflections from giving erroneous bearings. This would be 15-20_ for a vehicle and up to 500_ from a building. The loop is least affected due to its electrostatic shield. But unless it is resonant at the frequency, it will provide some signal reduction over a dipole. Its static field shielding makes it superior for close in work. It is frequently beneficial to start with a dipole or yagi until sufficient signal is received to use a loop.

c. "Hot and cold" is a useful although limited procedure. It consists of carrying a receiver, either personally or in a vehicle, tuned to the desired frequency. By trial and error, an area of maximum signal can be identified by observing the signal strength meter on the receiver as it is moved about. If the receiver has no meter, it probably would not have an RF gain control. The alternative is to detune the receiver intentionally in the presence of a strong signal, which will give the appearance of a weaker signal to the receiver. By judicious choice of moving location and selective detuning, the source usually can be located.

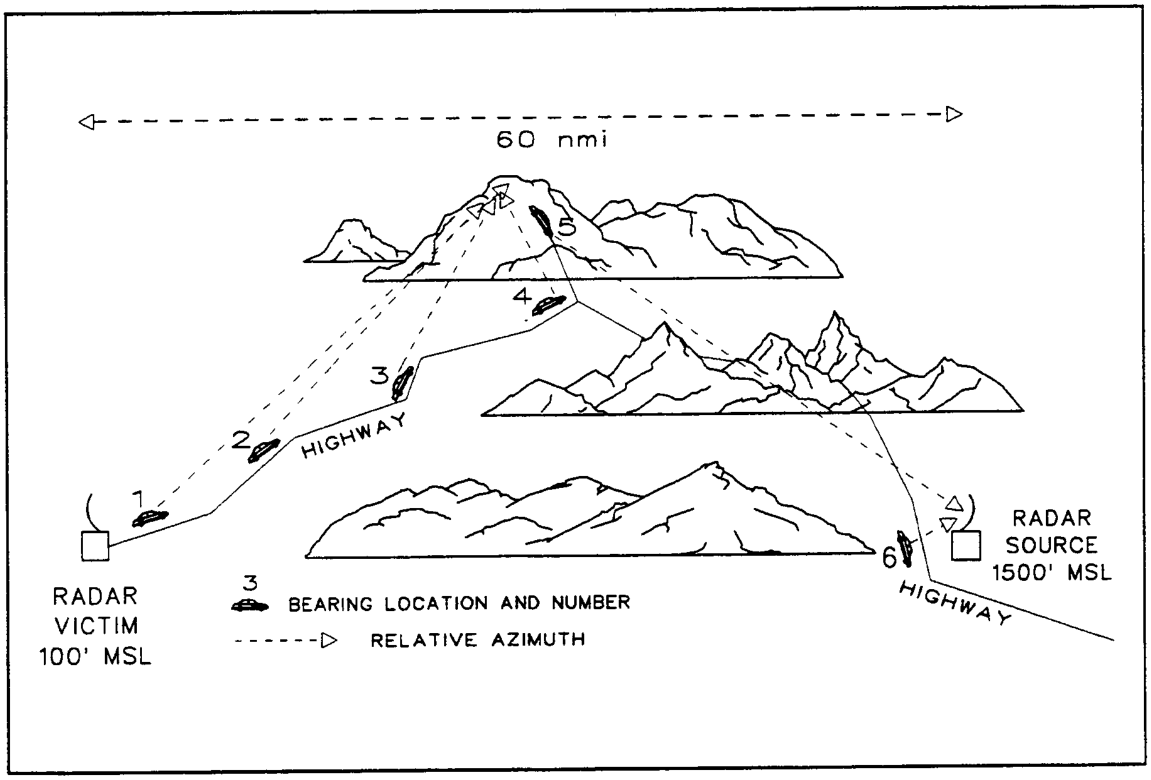
1407. DF (ABOVE 1000 MHZ). Microwave DF is normally limited to TACAN, radar or RCL bands. There is no fine line at 1000 MHz. But dipole and loop antennas become progressively ineffective for DF much above 300 or 400 MHz and yagis above about 1,000 MHz. Horn antennas start around 1000 MHz (1 GHz). These or helical equivalents are normally used, and because of antenna pattern configuration, the maximum signal is used for DF.

a. If the signal is TACAN or other steady state radiation, the source is located by triangulation as described in paragraph 1406. A horn or helical antenna is unidirectional, so even the first bearing indicates the right direction (allowing for reflections). A horn is polarized, so it must be rotated on its directional axis to determine the polarization of the incoming signal. A helical is not polarization sensitive, except where the source is reverse helical. In this case, the received signal is greatly attenuated by the reverse polarization of the receiving antenna.

b. If the signal is a rotating radar, the DF procedure is more complex. Because the DF receiver is illuminated for only milliseconds every 4 to 12 seconds on the average, some means is required to denote small differences in received signal as the horn direction is changed. If a field strength meter is used, the direct peak detection hold function should be used, since each illumination peak will be held for a few seconds. This allows visual noting and will permit signal level differences as small as 1 dB to be seen. If a general purpose receiver is used, a high-speed recorder such as the Techni-Rite Model 711 attached to the Y output or detected signal will permit the same observation in real time.

(1) The horn or helical antenna should be changed 10° to 15° at a time and the received level noted. Allow two or three passes to be observed at each azimuth before shifting. This will allow peculiar propagation such as beam fly-through by passing aircraft to be averaged out. Also, the FMO viewing a peak in azimuth should not immediately assume it is the bearing. Complete the whole 360° check. The first peak seen may be only a reflection or a minor lobe of the receive antenna. The real peak should stand out significantly. Another aid in discriminating between direct and reflected signals is that at microwave frequencies reflected signals off flat surfaces shift polarity 90°, but reflections off rough surfaces such as mountains, may change anywhere between 0° and 90°. The efficiency of the DF relies almost totally upon the skill and judgment of the user.

FIGURE 14-2. RADAR INTERFERENCE DF EXAMPLE.



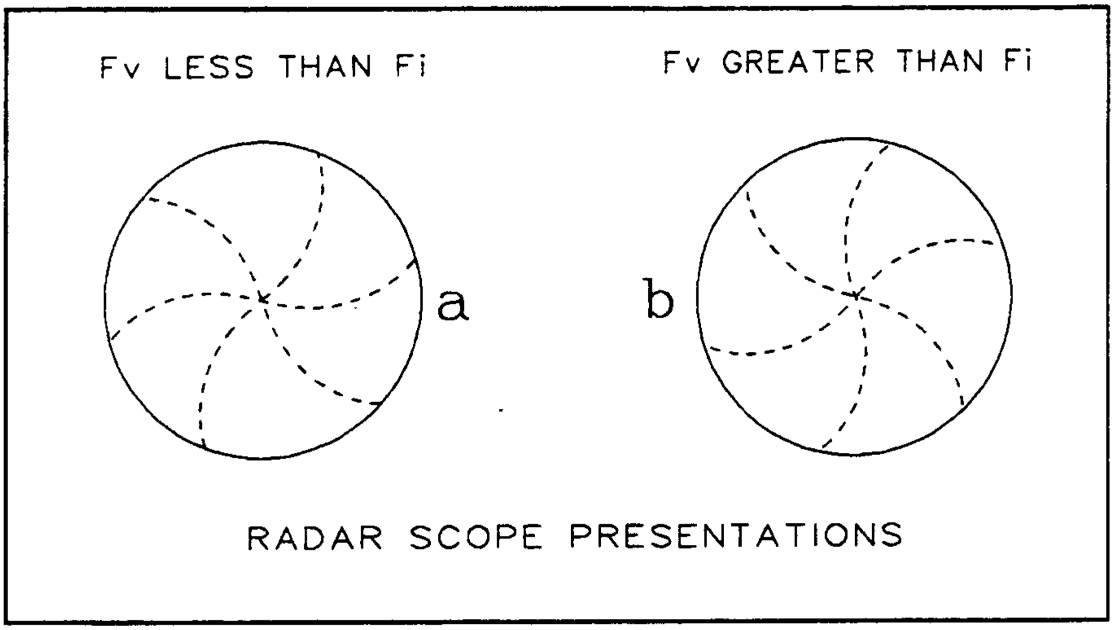
(2) A radar interference signal might be chased for miles in a continuing direction, only to find it to change abruptly concurrent with a marked increase in received signal strength. An actual example is shown in figure 14-2.

(3) The original bearings (1) through (4) in figure 14-2 all showed the same general area source and for 30 nmi converged on a point. This was because at the lower elevations, the only signal that the victim radar and the DF RFIM van could receive was that reflected from the mountain. But upon arrival near the converging point, the bearing suddenly shifted and the level greatly increased. The RFIM van receiver was now high enough to see over the hills that blocked direct reception of the interferer site. The victim radar received its interference by reflection from the large 10,000¢ mountain.

1408. "RUNNING RABBIT" INTERFERENCE. Paragraph 1405 mentions the type of interference that occurs when two search radars of fixed PRR's are operated in proximity. The dotted line spirals, running out from or into the center of the radar scope display indicate this type of radar interference. It most likely would happen near a military base or training area where frequent changes of radars are made by transient troop groups. There is a formula which will permit the FMO to determine the PRR of the interferer radar, since the FAA PRR will be known.

a. The first parameter needed is to determine whether the "rabbits," which actually are presentations of the difference in PRR's, are faster or slower than the FAA victim radar. The second parameter is the number of "rabbits" per radar sweep. The patterns for each condition are shown in figure 14-3. Shown below is the calculation for an interferer's PRR.

FIGURE 14-3. RUNNING RABBITS PATTERNS



b. When the PRR's are fairly close,

$$f_i = f_v \pm RS$$

where:

f_i = PRR of interferer radar in pps
f_v = PRR of victim radar in pps
R = Azimuth scan rate of victim radar in r/s
S = Spirals/revolution on victim radar scope presentation

c. For example:

$f_i = f_v \pm RS$
Victim radar PRR = 360 pps
Victim radar azimuth scan rate = 15 r/min = .25 r/s
Victim radar scope presentation shows 6.0 spirals/revolution

thus:

$$f_i = f_v \pm (6.0 \times .25)$$

$$= f_v \pm 1.5$$

f_i = 361.5, if the rabbits are as in presentation a of figure 14-3

= 358.5, if the rabbits are as in presentation b of figure 14-3

1409. ELECTRONIC COUNTERMEASURES (ECM) interference. DOD conducts frequent flights radiating for ECM missions, covering very large geographic areas. These emissions can be sources of serious RFI problems. The procedures are covered in chapter 18.

1410. POWER LINE INTERFERENCE. This interference is a particularly difficult source to locate. When a power line "carries" interference, it acts as a Beverage antenna and can conduct the RFI for miles along its lines. (A Beverage antenna is one straight wire fed at one end that is many wavelengths long, usually 7 or more. This configuration results in the antenna main radiation lobe being in the approximately the same direction as the wire.) The RFI source can be caused by a motor arcing at a farm or factory. It could be an arcing insulator on the power line. But once generated, because of the length of the power line which acts as a Beverage antenna, the interfering signal can be carried for miles along the line as standing waves. This type of problem is best solved by using the RFIM van or other equipped vehicle and "cruising" the line coming into the facility, and other lines nearby.

a. If it sounds like an electric motor, it could be anywhere from next door to several miles away, depending on how strong the brush arcing and the current drawn by the motor. Driving the RFI vehicle along the line feeding the facility will show a gradually increasing/decreasing average signal, although there frequently may be a small increase as each power pole is passed.

b. Using hot-and-cold DF techniques, the area or building source should be located within a reasonable period of time. When found, it should be brought to the attention of the operator, then of the utility company which supplies the service. Whether resolution is accomplished depends a great deal on the persuasiveness of the FMO and the ability to get cooperation.

c. Electric motor RF noise can be cured only by fixing the problem at its source, probably with power line filters or additional or better grounding at the motor. FCC has no jurisdiction in this matter at present.

d. If it sounds like intermittent arcing, it probably is a cracked or broken insulator on a pole crossarm. The utility company should be notified, stressing the aviation safety of life and property aspect. In any event, the FMO should make an effort to locate the problem. The utility company may have an "interference" group, but if so, generally they are understaffed so that resolution may take a long time. If the FMO can locate it and report the pole to the utility company, resolution should be prompt. Since an arcing insulator can lead to a pole fire, a utility company normally will take immediate action.

e. Use the RFIM van or other equipped vehicle (see manual reference in paragraph 1400) to "cruise" the line. In the general area of the insulator, there will be a marked increase in RF noise. It might sound ludicrous, but a hammer and a portable receiver are the best tools to locate the offending insulator. By carrying the portable receiver, the FMO can check the poles with the highest RF noise radiation. Standing next to the pole, a moderate blow of a good sized hammer will send sufficient vibrations up the pole to rattle the insulators. If the pole struck is the offender, the noise in the receiver will tremendously increase momentarily. On occasions, the arcing might even stop for a while until some other vibration sets it off. Once it has been located, note the location and the pole number so that it can be reported to the appropriate utility company.

f. If an ultrasonic detector is a component of the RFI equipment complement, it is another tool that can be used with great effect in tying down the arcing spot. After narrowing the area with a vehicle, the ultrasonic detector is pointed at individual crossarms and insulators from the ground position. Since the detector uses a parabolic reflector, the ultrasonic source can be pinpointed by aural and level meter means via a bore sight, sometimes down to the specific insulator. When located, it should be reported promptly to the utility company.

g. Insulator arcing may occur at any time, but frequently starts after a long dry period when dust and dirt accumulate on the surfaces. The first rain, if heavy enough to clean the insulators thoroughly, may clear up the problem for a time. A light first rain after a long dry spell can make matters worse by washing dirt into a crack, setting up an even better arcing path.

h. If the source is power line arcing, as opposed to being caused by some electrical device tied to the line, the FCC has determined they do have jurisdiction and may be of help. Contact with the utility company first is recommended. Contact the FCC only if the company does not cooperate.

1411. DIGITAL RADIO SYSTEMS. Commercial digital radio systems, especially microwave links, are being implemented across the country. Because of the decreased resistance of some digital radio receivers to certain types of RFI, FMO's need to be aware that there may be increasing numbers of complaints from commercial vendors concerning RFI to their systems. FMO's receiving such complaints need to first evaluate the accused (FAA) interference source to assure that it is operating within specifications. If the FAA system is within parameters, then the FMO may help the commercial vendor in whatever manner possible, as long as no expense is incurred to the FAA. If the victim is a federal agency, including military, plan to work with that agency in the same manner, but notify ASR early-on in the case.

1412. ELT PROBLEMS. Since their introduction, ELT's have caused a considerable amount of interference by false activations. Since they are on the emergency frequencies 121.5/243.0 MHz, they must be located and shut down quickly to keep the channels clear for legitimate ELT use by downed aircraft.

a. AT facilities will almost always be the first to know if a false activation occurs, since it mostly occurs on an airport. If it is very strong, AT should not only notify the SAR people, the nearest ARTCC and the regional duty officer, but also the appropriate SMO and the FMO. All SMO's have been supplied with hand carried ELT locators. They or other hand-held DF receivers can be used to locate the offending ELT. The hand-held DF supplied FMO's and SMO's is ideal for ELT location. Sometimes an accidentally triggered ELT may be in the trunk of a personal car, taken home by the pilot, or as has happened, been set off by rough handling in shipping. An accidentally triggered ELT may be found at nearly any location, even far away from airports.

b. In any event, the ELT must be silenced as quickly as possible by whomever can accomplish it. The FCC can be called for assistance, but this should be as a last resort and only if the FAA personnel cannot locate it themselves. Once found, it must be reported to the duty officer and the appropriate AT manager whose facility first reported it. By national agreement, all ELT's heard are assumed to be a downed aircraft until proven otherwise.

c. If the ELT is located in an aircraft, do not enter it. The local General Aviation District Office (GADO) or Air Carrier District Office (ACDO) and the regional duty officer shall be notified as to the aircraft identification. It is their job to contact SAR and the owner to silence it.

1413. RECORDS OF UNUSUAL PREVIOUS CASES. While all cases must be reported (paragraph 1401), unusual or unique case records can provide a wealth of material which can be used to save time in resolving similar cases. All FMO's are requested to submit brief narrative descriptions of unusual resolved problems or alerts to ASR so that they can be disseminated to other regional FMO's. In addition, audio tape recordings should be made of new or unusual cases and forwarded to ASR for inclusion in the national RFI sounds bank. If the source has a particularly unusual video presentation on an oscilloscope or SA, a video tape of the RFI sent to ASR would be useful.

1414. thru 1499. RESERVED.